Reducibility and Thermal Scaling in Nuclear Multifragmentation

L.G. Moretto, R. Ghetti, L. Phair, K. Tso, and G.J. Wozniak
Nuclear Science Division, Lawrence Berkeley National Laboratory

Recent studies have revealed the existence of a number of reducibility and thermal scaling properties in nuclear multifragmentation. The probability of emitting n intermediate-mass fragments is found to be *reducible* to the probability of emitting a single fragment through the binomial expression [1,2]. The resulting one fragment probability shows *thermal scaling* by producing linear Arrhenius plots [1–3].

Similarly, the charge distributions associated with n-fragment emission are *reducible* to the one-fragment charge distribution [4]. *Thermal scaling* is also observed [4]. The reducibility equation contains a constant whose value, zero or positive, can be related to a univariant (two phases) or bivariant (one phase) regime [5].

The light fragment particle-particle angular correlations also show *reducibility* to the single-particle angular distributions as well as *thermal scaling* [6]. A mass scaling associated with the angular correlations suggests emission from several small sources ($A \approx 20$).

The limits of applicability of scaling and reducibility are discussed in ref. [7] as well as their implications for the mechanism of multifragmentation.

The picture of multifragmentation, as it appears in ref. [7], is still sketchy and incomplete. However, we believe we have succeeded in unveiling important features which may be the key to deeper understanding.

The pervasive aspect of *reducibility* indicates that, whatever the mechanism, the fragments are emitted essentially independent of one another. Thus we have shown that the probability P_n of emitting n fragments can be reduced to the probability of emitting a single fragment through the binomial equation. Similarly the n fragment charge distributions can be reduced to the one fragment charge distribution. Furthermore, the particle-particle angular correlation can be reduced to the individual particle angular distributions.

In all the above quantities, reducibility is somehow restricted by what we may call "dynamical constraints". For the emission probabilities, the constraint is the binomial parameter m (the number of "throws"), indicative either of a dynamical time window, or of the finite source size.

For the charge distributions, reducibility is restricted by the parameter c (see refs. [4,5]), which seems to indicate some special way of enforcing charge conservation. We speculate that its transition from near zero to a finite value with increasing energy could be an indication of a transition from phase coexistence (liquid-vapor) to a single phase (vapor).

Finally, the angular correlations violate reducibility at small relative angle where particle-particle interactions become manifest [6].

These broad features of reducibility speak to the near independence of fragment emission but not to its mechanism.

Thermal scaling instead makes a clear statement about the fact that the elementary probabilities entering in the n fragment emission probabilities, the n fragment charge distributions, and the two fragment angular correlations are *thermal*. In other words, these probabilities have the form of a Boltzmann factor and clearly portray its characteristic energy dependence (Arrhenius plots).

Thus the resulting picture is tantalizingly close, but not quite that of a compound nucleus emission. Apparently sources are dynamically generated which, within dynamical constraints of time and size, emit fragments in a thermal manner. Among the potential fruits that can be reaped from the pursuit of the analysis outlined so far are dynamical features of source formation, size and lifetime, as well as static features like barriers, source sizes and densities.

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